EXAMINATION OF CLOSING THE EXISTING HIGHWAY MAINTENANCE GARAGE AT HAMLIN, IOWA

FINAL REPORT

Prepared By
Office of Transportation Research
Planning and Research Division
Iowa Department of Transportation
August 1983

Iowa Department of Transportation

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FINAL REPORT

Project Control No. 90-83-8303-722

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Office of Maintenance

Highway Division

By

Office of Transportation Research

Planning and Research Division

Iowa Department of Transportation

(515) 239-1140

August 1983

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I. ABSTRACT

An optimum allocation model has been utilized to examine the existing allocation of highway segments to maintenance garages in the Hamlin study area. The model has also been used to evaluate the financial effect of closing the garage at Hamlin.

The examination of the study area shows that only three of 48 highway segments should be reallocated at an annual operational savings of approximately $1,400.

The study concludes there would be an annual operational savings of approximately $28,700 if the garage at Hamlin were closed.

II. INTRODUCTION AND OBJECTIVES

A linear programming model is used to optimally assign highway segments to highway maintenance garages, using existing facilities. The model is also used to determine possible operational savings associated with closing the highway maintenance garage at Hamlin.

The study, "An Optimum Allocation Approach to Closing or Relocating Highway Maintenance Garages in Iowa," (1) had successfully identified a model referred to as an "optimum allocation model." This model was developed by utilizing the highway maintenance-related data currently available at the Iowa Department of Transportation. It can optimally assign highway segments to maintenance garages and evaluate the financial effect of closing or relocating specified maintenance garages in a given study area.

The current project was undertaken at the request of the Office of Maintenance. The objective of this study was to utilize the "optimum allocation model" to examine the existing highway maintenance garage locations in Hamlin area. The model was used to:

1. Optimally assign highway segments to maintenance garages in the study area.
2. Evaluate the financial effect of closing the garage at Hamlin.

III. THE OPTIMUM ALLOCATION MODEL

The following subsections describe the assumptions required by the optimum allocation model, the study area to be investigated using the model, and the steps necessary to get the type of data usable by the model.

A. Assumptions

1. For the purpose of this study and with the concurrence of the Office of Maintenance, highway maintenance vehicles are assumed to travel at average speeds of 35 mph for snow and ice control activities and 40 mph for other maintenance activities. These average speeds are used to derive a weighted average speed which is then used to estimate travel times.
2. The highway maintenance cost associated with a route in a given maintenance area is assumed to be uniformly distributed along the route.
3. Any highway segment formed is represented by its midpoint. Thus the highway maintenance cost of a segment is assumed to be concentrated at its midpoint. Also, travel times are calculated from garages to midpoints of highway segments.
4. The travel times from garage "X" to segment "Y" and from segment "Y" to garage "X" are assumed to be the same.
5. The cost of servicing a highway segment from a maintenance garage is assumed to vary as a function of travel time between the garage and the segment. In the optimum allocation model, the relationship has been quantified by the use of "cost multipliers" (1).
6. The garages in the study area are assumed to have unlimited capacities. This means the garages can be expanded, if necessary, to service all the segments optimally assigned to them.

7. Whenever a garage relocation possibility is studied, the garage overhead cost before and after its relocation is assumed to be the same.

8. Capital costs and staffing needs are not considered.

B. Study Area

The study area for this project was provided by the Office of Maintenance. The study area is the Hamlin part of Iowa and is shown in Appendix 1. It consists of six "active" maintenance garages.

C. Source of Data

The fiscal year 1982 labor and equipment costs for all the routes in the study area were supplied by the Office of Maintenance. The overhead costs for the garages in the study area were also supplied by the same office. These costs are shown in Appendix 4.

D. Basic Maintenance and Basic Overhead Costs

The fiscal year 1982 labor, equipment and overhead costs were adjusted for inflation to reflect what these costs would be if the same maintenance activities were done in fiscal year 1983. The adjustments were made as shown below.

Labor - - - 8%

Equipment - - - 10%

Overhead - - - 8%

These inflation rates were provided by the Office of Maintenance.

The inflation-adjusted labor and equipment costs for a route were combined to a form a single cost. This single cost was referred to as the "basic maintenance" cost for that route. The inflation-adjusted overhead cost for a garage was simply referred to as the "basic overhead" cost of the garage.

The optimum allocation model requires knowledge of the overhead cost of each maintenance garage in the study area. Sometimes such data is not available because in certain maintenance areas the overhead costs for some garages are combined during the record-keeping process. In such situations it was recommended by the Office of Maintenance that the overhead costs of the garages involved be determined according to the relative percentages of the number of persons and/or the number of miles of highway associated with each garage.

E. Highway Segments

All the routes in each study area were broken up into suitable segments according to the following criteria:

1. Segments should not be more than 25 miles long (per Office of Maintenance).
2. Segments should be reasonably short, so as to increase the accuracy of the model.
3. Segments should be reasonably long, so as to minimize the computation time involved and hence reduce the costs associated with the model.

A total of 48 segments, ranging from one mile to 22 miles in length, were formed in the study area. These segments are shown in Appendix 2.

F. Weighted Average Speed

The optimum allocation model is sensitive to small changes in speed (1), and thus is sensitive to small changes in travel time. For a given highway segment the travel time from a given garage to the segment is generally greater for snow and ice control activities than it is for the other maintenance activities. Consequently, it would be erroneous to use a "simple" average speed for all the maintenance activities.

To reduce this type of error, Nkansah and Baig (1) suggested that a "weighted" average speed be used. That "weighted" speed is derived from: the average speeds pertaining to snow and ice control activities and the other maintenance activities; and the relative percentages of snow and ice control activities and the other maintenance activities.

In this study a weighted average speed of 38 mph was used. It was determined as shown below (all data provided by the Office of Maintenance):

% of snow and ice control activities	=	42.5%
Average speed for snow and ice control activities	=	35 mph
Average speed for other maintenance activities	=	40 mph

Therefore,

$$\text{Weighted average speed} = (0.425)(35) + (0.575)(40)$$
$$= 14.875 + 23$$
$$= 38 \text{ mph}$$

G. Travel Time-Adjusted Costs

One set of travel times corresponding to the study area was calculated using a weighted average speed of 38 mph and the distances as shown in the July 1981 Maintenance Area Responsibility Maps (2). These travel times were then utilized to adjust the basic maintenance costs of each highway segment through the cost multiplier concept (1).

IV. THE OPTIMUM ALLOCATION MODEL RESULTS

The optimum allocation model was used to investigate the given study area. The following subsections describe the results obtained.

A. Existing and Optimum Allocations

The "existing allocation" refers to the current maintenance areas in the study area. These maintenance areas were determined by the Office of Maintenance without the use of the optimum allocation model. These two allocations (existing and optimum) were compared on the basis of operating costs only.

The operating costs pertaining to the optimum allocation were determined by applying the optimum allocation model to the study area. To ensure compatibility in cost, the operating costs pertaining to the existing allocation were also determined from travel time-adjusted costs. In this case, however, the travel time-adjusted costs were calculated by utilizing the cost multipliers and the travel times as determined by the existing allocation system. A summary of the results is shown in Table 1 on the next page.

TABLE 1

SEGMENTS REALLOCATED UNDER OPTIMUM ALLOCATION
IN HAMLIN STUDY AREA

	Existing Allocation		Optimum Allocation		Cost Savings Using Optimum Allocation (Dollars/Yr.)
Segment No.	Assigned to Garage at:	Operating Costs* (Dollars/Yr.)	Assigned to Garage at:	Operating Costs* (Dollars/Yr.)	
16	Atlantic	$ 124	Adair	$ 120	$ 4
17	Atlantic	20,743	Adair	19,668	1,075
18	Atlantic	5,630	Adair	5,320	310
				Total =	$1,389

* Operating costs are based on travel time-adjusted costs.

Table 1 shows only three segments (segment Nos. 16, 17 and 18) were reallocated under optimum allocation procedures, resulting in annual savings of approximately $1,389. This savings is very small. Thus, it can be concluded that the current allocation of highway segments to existing garages within the study area is good for all practical purposes.

B. Closing of Garage

The optimum allocation model was used to evaluate the financial effect of closing the garage at Hamlin. The results are shown in Table 2.

TABLE 2

COST ANALYSIS OF CLOSING HAMLIN GARAGE
USING OPTIMUM ALLOCATION

(1) Item	Operating Costs* (2) Garage(s) Not Closed (Dollars)	(3) Garage(s) Closed (Dollars)	(4) Increased Travel Cost (Dollars) (3) - (2)	(5) Overhead Cost of Garages Closed (Dollars)	(6) Estimated Savings (1983 Dollars) (5) - (4)
All Garages	$938,360				
Hamlin		$951,394	$13,034	$41,757	$28,723

* Operating costs are based on travel time-adjusted costs.

Table 2 shows closing the garage at Hamlin increased travel cost by approximately $13,034 per year. However, there is a cost savings of approximately $28,723 per year.

The optimal assignment of highway segments to garages in the study area for the case investigated is shown in Appendix 5.

V. CONCLUSION

In this study an optimum allocation model has been used to examine the highway maintenance area served by Hamlin study area.

The results show that the existing allocation of highway segments to maintenance garages is good for all practical purposes. In fact, only three of 48 highway segments were reallocated under optimum procedures, resulting in an annual operational savings estimate of approximately $1,400.

There would be annual operational savings estimate of approximately $28,700 if the garage at Hamlin were closed.

These estimated annual operational cost savings are subject to the assumptions and limitations of the study as discussed in Sections III. A. and VI., respectively.

VI. LIMITATIONS OF STUDY

The accuracy of the cost savings reported in this study is subject to:

1. The reliability of the historical cost data provided for use in this study.
2. The accuracy of the apportionment of an overhead cost in cases where two or more garages have a combined overhead cost.
3. The accuracy of the average speeds of maintenance vehicles (for various maintenance activities) used to calculate the weighted average speed.
4. The garage overhead costs before and after its relocation are assumed to be the same.
5. Capital costs and staffing needs are not considered.

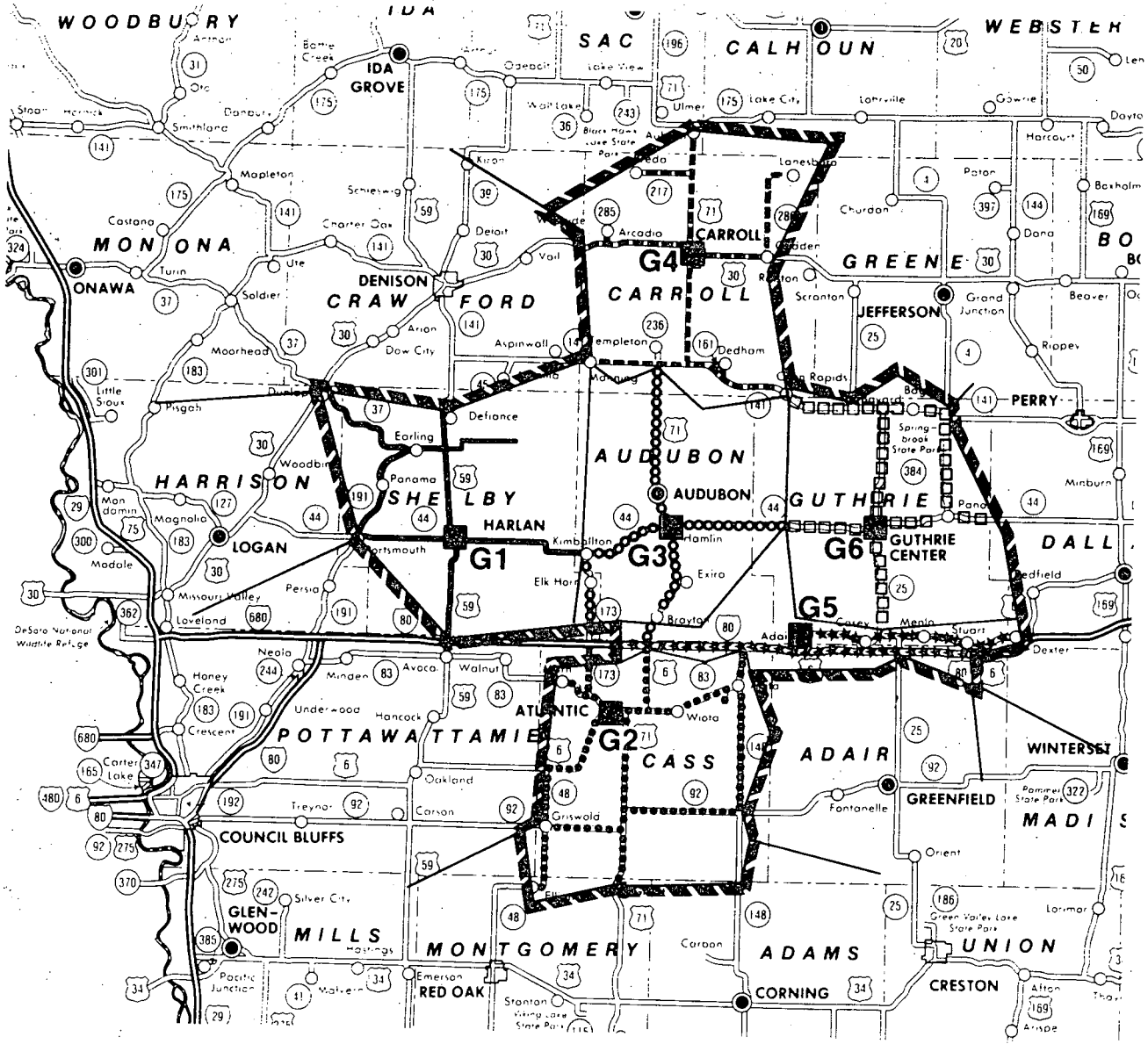
VII. REFERENCES

1. Paul T. Nkansah and Saleem Baig. An Optimum Allocation Approach to Closing or Relocating Highway Maintenance Garages in Iowa. Final Report. Office of Transportation Research, Planning and Research Division, Iowa Department of Transportation. June 1981.

2. Iowa Department of Transportation, Office of Maintenance, Maintenance Area Responsibility Maps. July 1981.

APPENDICES

Appendix 1
Hamlin Study Area Showing
Existing Highway Segments Allocations

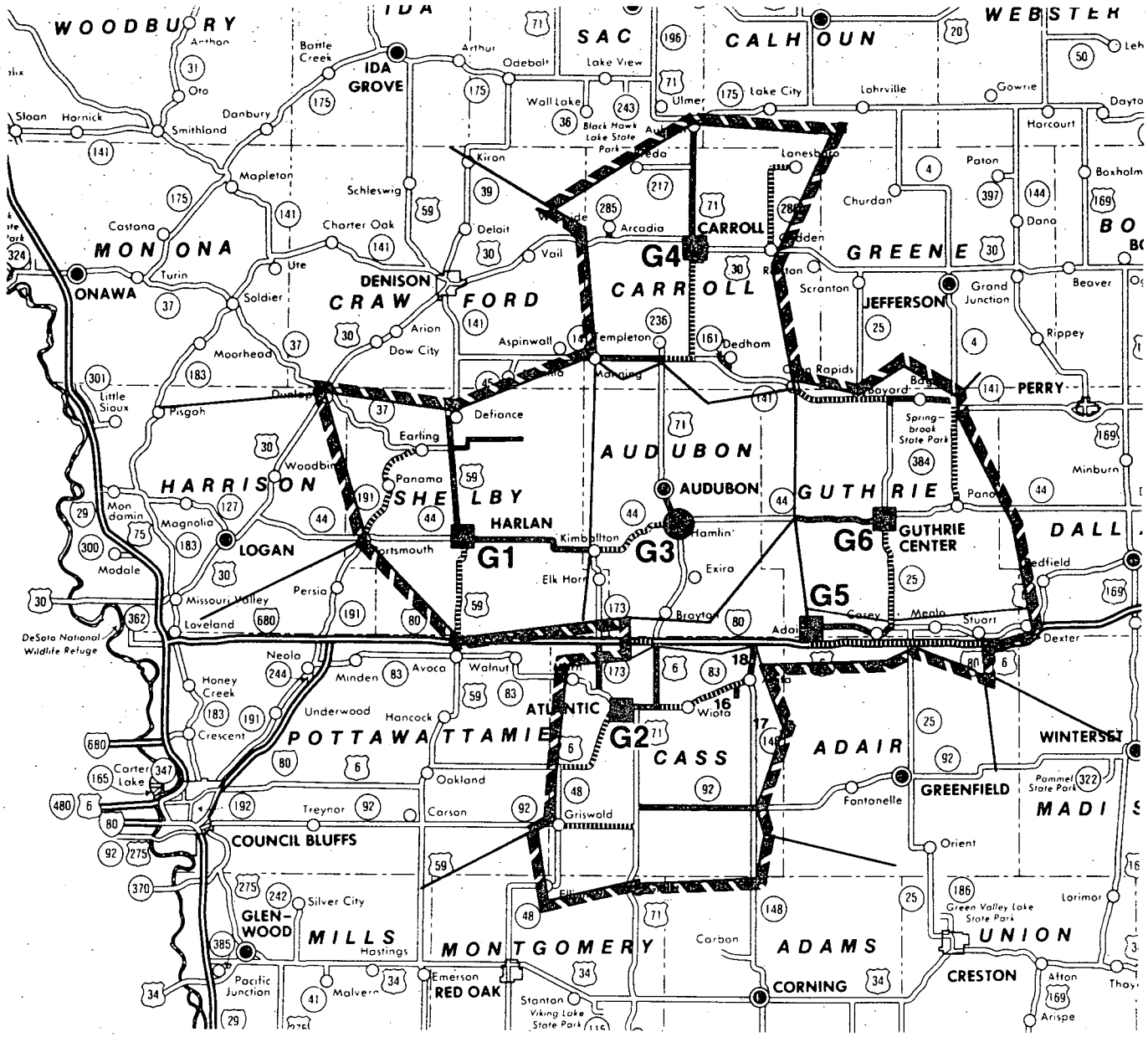


Segment Served	Location
▬▬	Harlan (G1)
••••	Atlantic (G2)
ooo	Hamlin (G3)
- - -	Carroll (G4)
★★★	Adair (G5)
□□□	Guthrie Center (G6)

Legend:

- ■ Existing garage
- G Garage number
- Study boundary area

Appendix 2
Hamlin Study Area Showing
Optimal Highway Segments Allocations
Six Garages and 48 Highway Segments

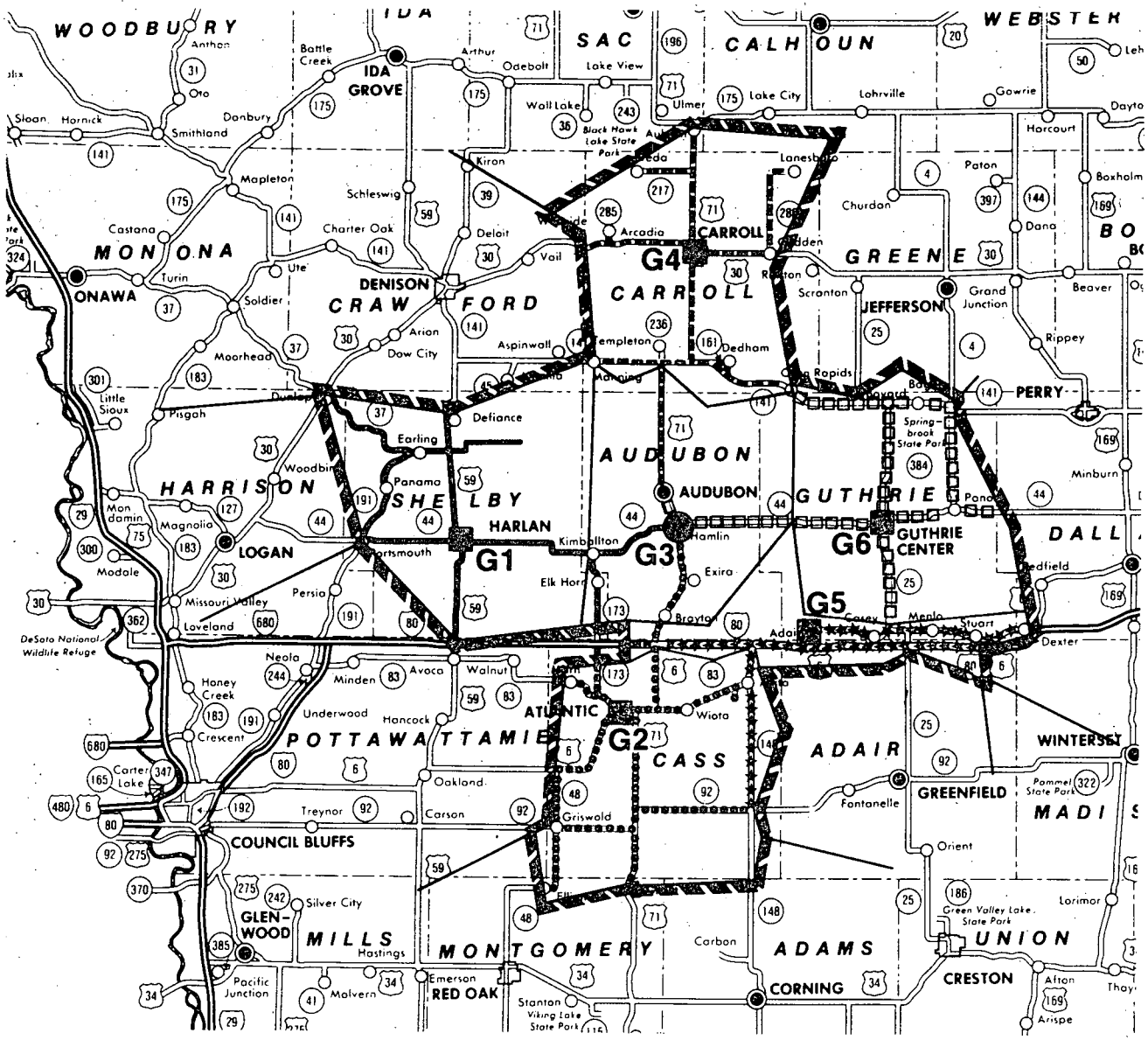


Garage	Location
G1	Harlan
G2	Atlantic
G3	Hamlin (to be closed later)
G4	Carroll
G5	Adair
G6	Guthrie Center

Legend:

- Existing garage
- Garage to be closed
- G — Garage number
- Highway segments
- Study boundary area
- oo — Segment number (Reallocated)

Appendix 3
Study Area Showing Optimal Highway Segments Allocations (Hamlin Closed)



Segment Served	Location
▬▬	Harlan (G1)
••••	Atlantic (G2)
	Hamlin (G3 closed)
- - -	Carroll (G4)
★★★	Adair (G5)
□□□	Guthrie Center (G6)

Legend:

- ■ Existing garage
- ● Closed garage
- G Garage number
- Study boundary area

APPENDIX 4

FISCAL YEAR 1982
LABOR, EQUIPMENT AND OVERHEAD COSTS
FOR THE ROUTES AND GARAGES IN HAMLIN STUDY AREA

Location and Number of Garages	1982 Garage Related Costs (Dollars)	Routes Served by Garage	1982 Labor Cost (Dollars)	1982 Equipment Cost (Dollars)
Carroll (3303)	$48,427	30	$29,112	$ 2,511
		71	29,558	24,951
		141	16,918	14,111
		161	1,005	788
		217	552	470
		236	988	1009
		285	33	37
		286	2,542	3,034
Adair (4401)	57,302	80	106,405	85,438
		925	24,893	20,240
Hamlin (4403)	41,757	44	23,018	18,859
		71	44,183	38,204
		173	3,887	2,755
Atlantic (4404)	74,590	6	16,889	16,325
		48	7,895	5,698
		71	19,242	20,947
		83	19,608	21,257
		92	24,555	23,972
		148	13,726	13,522
		173	5,691	5,255
		6,669	86	46
Guthrie Center (4409)	48,561	4	4,504	1,986
		25	29,212	20,486
		44	24,856	16,894
		141	24,036	16,197
Harlan (4410)	43,847	37	19,170	14,621
		44	50,171	39,072
		59	23,214	19,702
		191	8,287	6,459

Source: Office of Maintenance, Highway Division, Iowa Department of Transportation.

APPENDIX 5

OPTIMAL ASSIGNMENT OF HIGHWAY SEGMENTS TO GARAGES IN HAMLIN STUDY AREA

Highway Segment No.	Garage					
	G1	G2	G3	G4	G5	G6
1	x					
2	x					
3	x					
4	x					
5	x					
6	x					
7		x				
8		x				
9		x				
10		x				
11		x				
12		x				
13		x				
14		x				
15		x				
16					x	
17					x	
18					x	
19	x3		x			
20	x3		x			
21		x3	x			
22			x			x3
23			x			x3
24			x	x3		
25				x		
26				x		
27				x		
28				x		
29				x		
30				x		
31				x		
32				x		
33				x		
34				x		
35				x		
36					x	
37					x	
38					x	
39						x
40						x
41						x
42						x

APPENDIX 5 (continued)

Highway Segment No.	Garage G1	G2	G3	G4	G5	G6
43						x
44						x
45						x
46	x					
47		x				
48					x	

Legend: x - Optimal Assignment of Segment to Garage

x_i - Optimal Assignment of Segment to Garage When Garage "i" Is Closed

Appendix 6

Sample Output of the MPSX Computer Program Using a Partial Data Set

Notes:

```
0         1         2         3         4         5         6         7         8         9         10        11        12        13
1234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890123
•MPSX-PTF 19..  EXECUTOR.  MPSX  RELEASE 1  MOD LEVEL 6                                                    PAGE    6 -  83/045
    X1        COST          21634.70000   NOD1          1.00000
    X2        COST         195200.0000    NOD1          1.00000
    X3        COST         195200.0000    NOD1          1.00000
    X3        CLOS3            1.00000
    X4        COST         195200.0000    NOD1          1.00000
    X5        COST         195200.0000    NOD1          1.00000
    X6        COST         195200.0000    NOD1          1.00000
    X7        COST          13914.30000   NOD2          1.00000
    X8        COST         128440.0000    NOD2          1.00000
    X9        COST         128440.0000    NOD2          1.00000
    X9        CLOS3            1.00000
    X10       COST         128440.0000    NOD2          1.00000
    X11       COST         128440.0000    NOD2          1.00000
    X12       COST         128440.0000    NOD2          1.00000
    X13       COST          48216.80000   NOD3          1.00000
    X14       COST         470408.0000    NOD3          1.00000
    X15       COST         470408.0000    NOD3          1.00000
    X15       CLOS3            1.00000
    X16       COST         470408.0000    NOD3          1.00000
    X17       COST         470408.0000    NOD3          1.00000
    X18       COST         470408.0000    NOD3          1.00000
    X19       COST          13412.80000   NOD4          1.00000
    X20       COST         134128.0000    NOD4          1.00000
    X21       COST         134128.0000    NOD4          1.00000
    X21       CLOS3            1.00000
    X22       COST         134128.0000    NOD4          1.00000
    X23       COST         134128.0000    NOD4          1.00000
    X24       COST         134128.0000    NOD4          1.00000
    X25       COST          30690.40000   NOD5          1.00000
    X26       COST         306904.0000    NOD5          1.00000
    X27       COST         306904.0000    NOD5          1.00000
    X27       CLOS3            1.00000
    X28       COST         306904.0000    NOD5          1.00000
    X29       COST         306904.0000    NOD5          1.00000
    X30       COST         306904.0000    NOD5          1.00000
    X31       COST          23981.60000   NOD6          1.00000
    X32       COST         239816.0000    NOD6          1.00000
    X33       COST         239816.0000    NOD6          1.00000
    X33       CLOS3            1.00000
    X34       COST         239816.0000    NOD6          1.00000
    X35       COST         239816.0000    NOD6          1.00000
    X36       COST         239816.0000    NOD6          1.00000
    X37       COST         118360.0000    NOD7          1.00000
    X38       COST          13216.90000   NOD7          1.00000
    X39       COST         118360.0000    NOD7          1.00000
    X39       CLOS3            1.00000
    X40       COST         118360.0000    NOD7          1.00000
    X41       COST         118360.0000    NOD7          1.00000
    X42       COST         118360.0000    NOD7          1.00000
    X43       COST          18016.0000    NOD8          1.00000
    X44       COST          19826.40000   NOD8          1.00000
    X45       COST         181616.0000    NOD8          1.00000
    X45       CLOS3            1.00000
    X46       COST         181616.0000    NOD8          1.00000
    X47       COST         181616.0000    NOD8          1.00000
```

X1 is the fraction of segment No. 1 allocated to garage No. 1. $21,634.7 is the travel time-adjusted cost from garage No. 1 to segment No. 1

X6 is the fraction of segment No. 1 allocated to garage No. 6. $195,200 is the travel time-adjusted cost from garage No. 6 to segment No. 1.

X7 is the fraction of segment No. 2 allocated to garage No. 1. $13,914.3 is the travel time-adjusted cost from garage No. 1 to segment No. 2, etc.

CLOS3 is the user supplied name for closing garage 3.

•MPSX-PTF19•• EXECUTOR• MPSX RELEASE 1 MOD LEVEL 6 PAGE 18 - 83/046

SECTION 2 - COLUMNS

NUMBER	•COLUMN•	AT	•••ACTIVITY•••	••INPUT COST••	••LOWER LIMIT•	••UPPER LIMIT•	•REDUCED COST•
51	X1	BS	1.00000	21634.70000	.	NONE	.
52	X2	LL	.	195200.00000	.	NONE	173565.30000
53	X3	LL	.	195200.00000	.	NONE	177823.00000
54	X4	LL	.	195200.00000	.	NONE	173565.30000
55	X5	LL	.	195200.00000	.	NONE	173565.30000
56	X6	LL	.	195200.00000	.	NONE	173565.30000
57	X7	BS	1.00000	13914.30000	.	NONE	.
58	X8	LL	.	128440.00000	.	NONE	114525.70000
59	X9	LL	.	128440.00000	.	NONE	118783.40000
60	X10	LL	.	128440.00000	.	NONE	114525.70000
61	X11	LL	.	128440.00000	.	NONE	114525.70000
62	X12	LL	.	128440.00000	.	NONE	114525.70000
63	X13	BS	1.00000	46216.80000	.	NONE	.
64	X14	LL	.	470408.00000	.	NONE	422191.20000
65	X15	LL	.	470408.00000	.	NONE	426448.90000
66	X16	LL	.	470408.00000	.	NONE	422191.20000
67	X17	LL	.	470408.00000	.	NONE	422191.20000
68	X18	LL	.	470408.00000	.	NONE	422191.20000
69	X19	BS	1.00000	13412.80000	.	NONE	.
70	X20	LL	.	134128.00000	.	NONE	120715.20000
71	X21	LL	.	134128.00000	.	NONE	124972.90000
72	X22	LL	.	134128.00000	.	NONE	120715.20000
73	X23	LL	.	134128.00000	.	NONE	120715.20000
74	X24	LL	.	134128.00000	.	NONE	120715.20000
75	X25	BS	1.00000	30690.40000	.	NONE	.
76	X26	LL	.	306904.00000	.	NONE	276213.60000
77	X27	LL	.	306904.00000	.	NONE	280471.30000
78	X28	LL	.	306904.00000	.	NONE	276213.60000
79	X29	LL	.	306904.00000	.	NONE	276213.60000
80	X30	LL	.	306904.00000	.	NONE	276213.60000
81	X31	BS	1.00000	23981.60000	.	NONE	.
82	X32	LL	.	239816.00000	.	NONE	215834.40000
83	X33	LL	.	239816.00000	.	NONE	220092.10000
84	X34	LL	.	239816.00000	.	NONE	215834.40000
85	X35	LL	.	239816.00000	.	NONE	215834.40000
86	X36	LL	.	239816.00000	.	NONE	215834.40000
87	X37	LL	.	118360.00000	.	NONE	105143.10000
88	X38	BS	1.00000	13216.90000	.	NONE	.
89	X39	LL	.	118360.00000	.	NONE	109400.80000
90	X40	LL	.	118360.00000	.	NONE	105143.10000
91	X41	LL	.	118360.00000	.	NONE	105143.10000
92	X42	LL	.	118360.00000	.	NONE	105143.10000
93	X43	LL	.	181616.00000	.	NONE	161789.60000
94	X44	BS	1.00000	19826.40000	.	NONE	.
95	X45	LL	.	181616.00000	.	NONE	166047.30000
96	X46	LL	.	181616.00000	.	NONE	161789.60000
97	X47	LL	.	181616.00000	.	NONE	161789.60000
98	X48	LL	.	181616.00000	.	NONE	161789.60000
99	X49	LL	.	169432.00000	.	NONE	152488.80000

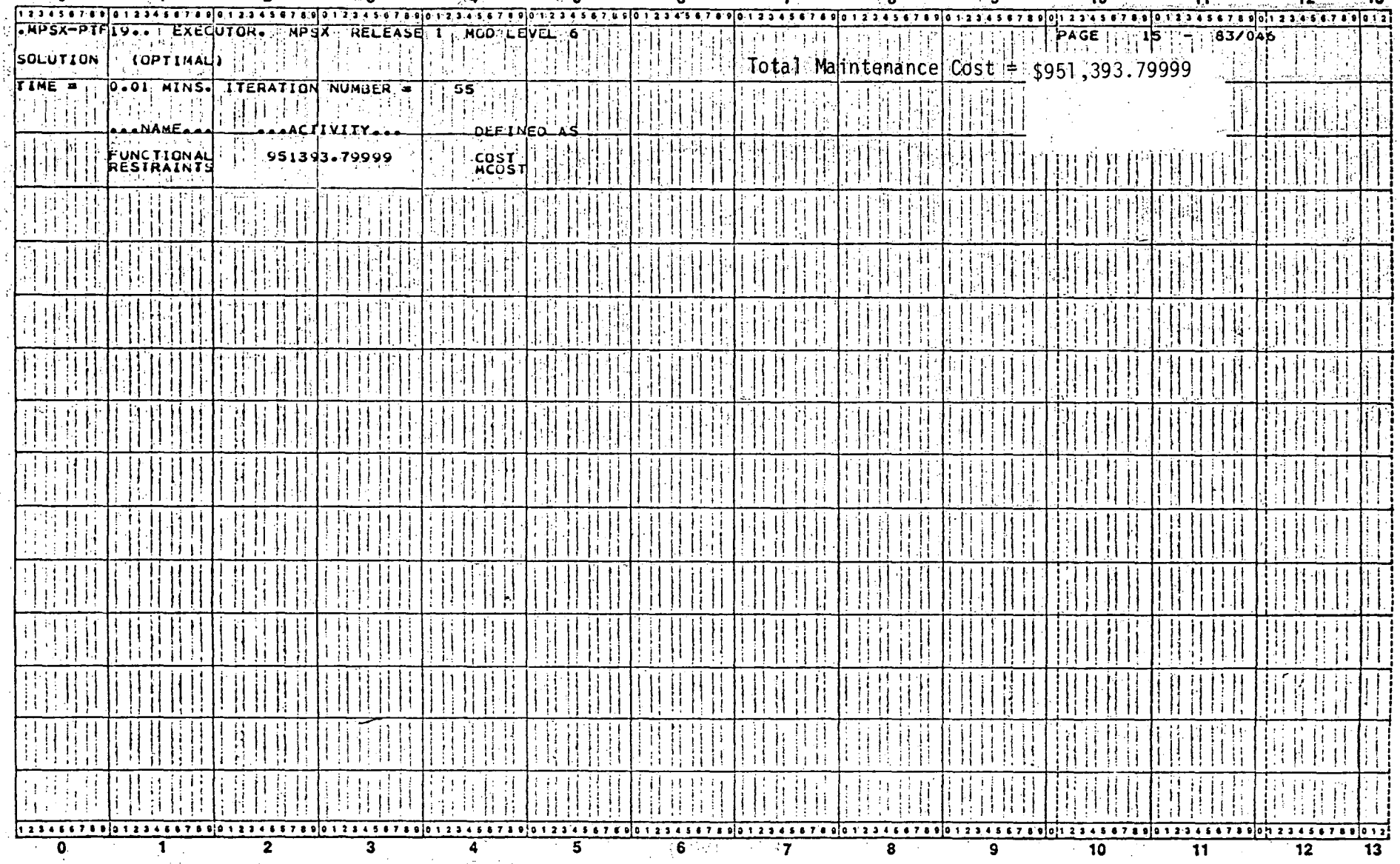
Notes:

Segment No. 1 is allocated to garage No. 1 with a service cost of $21,634.7. Segment No. 2 is allocated to garage No. 1 with a service cost of $13,914.3, etc.

The column "reduced cost" is the amount of savings in dollars associated with the given allocation.

Appendix 6 (Continued)

Notes:



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0    1    2    3    4    5    6    7    8    9    10   11   12   13
1234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012
•MPSX-PTF 19•• EXECUTOR• MPSX RELEASE 1 MOD LEVEL 6                                                    PAGE 15 - 83/045
SOLUTION (OPTIMAL)                                                  Total Maintenance Cost = $951,393.79999
TIME = 0.01 MINS. ITERATION NUMBER = 55

   •••NAME•••      •••ACTIVITY•••      DEFINED AS
FUNCTIONAL        951393.79999        COST
RESTRAINTS                            MCOST
1234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012
0    1    2    3    4    5    6    7    8    9    10   11   12   13
```

APPENDIX 7
SEGMENTS REALLOCATED UNDER OPTIMUM ALLOCATION
(HAMLIN STUDY AREA)

Highway Segment No.	Length of Segment (Miles)	Route No.	Originally Assigned to	Optimally Assigned to	*Basic Maintenance Costs (1983 Dollars)
16	7.23	6669	Atlantic	Adair	$ 144
17	13.02	148	Atlantic	Adair	23,048
18	3.76	148	Atlantic	Adair	6,650

* 1983 labor and equipment costs based on the 1982 cost adjusted for inflation.

APPENDIX 8
SEGMENTS REALLOCATED UNDER OPTIMUM ALLOCATION
(HAMLIN GARAGE CLOSED)

Highway Segment No.	Length of Segment (Miles)	Route No.	Originally Assigned to	Optimally Assigned to	*Basic Maintenance Costs (1983 Dollars)
19	9.82	173	Hamlin	Harlan	$ 7,229
20	10.41	44	Hamlin	Harlan	23,869
21	12.63	71	Hamlin	Atlantic	38,357
22	9.48	44	Hamlin	Guthrie Center	21,735
23	4.55	71	Hamlin	Guthrie Center	13,818
24	12.37	71	Hamlin	Carroll	37,568

* 1983 labor and equipment costs based on the 1982 cost adjusted for inflation.